> in turn was caused by the high inflow of P into Tenkiller from the watershed. This has led to a human health risk in drinking water of many residents along Tenkiller's shores."

On page 36 of the Cooke and Welch (2008a) report, the authors summarize their expert opinions:

> "Eutrophic and hypereutrophic states in Tenkiller would lead to large, entire-summer algal blooms, particularly blue-green algae, severely impacted potable water and associated human health risks from DBPs…"

Broken Bow Reservoir has been used by the plaintiffs' experts as an example of a reservoir with lower phosphorus inputs and a much higher quality of water than Lake Tenkiller. It is curious that Cooke and Welch did not present in their report a comparison of raw water TOC and distribution system values of TTHM and HAA5 for water utilities serving water from the two reservoirs. Two emails from Dr. Cooke made it clear that he knew that a comparison of DBP levels in water from the two reservoirs was important and that he looked at the DBP levels in tap water served from a Broken Bow Reservoir utility. In one email, he stated, "This list summarizes what I believe I will need for my portion of the THM report: 1. All THM and HAA5 data for finished water for each of the utilities on Tenkiller and Broken Bow…" In the other email he stated, "I am amazed at the very high THM values from Broken Bow. That reservoir is supposed to be our reference reservoir." A document produced by the plaintiffs to defendants contains TTHM and HAA5 data for the utility serving water from Broken Bow Reservoir (Cooke and Welch 2008b).

TOC data from the ODEQ SDWIS website (ODEQ 2008a) from raw water withdrawn from Broken Bow Reservoir averaged 2.7 mg/L over 6.7 years (January 2, 2002 to October 6, 2008). From the same data source, the average TOC value from 15 raw water sources for utilities using Lake Tenkiller was 2.2 mg/L over a four to six year period (2004-2008 and 2002-2008 depending on the utility records). Figure 15 compares the TOC levels in Lake Tenkiller with the TOC levels in Broken Bow Reservoir. These data show high TOC values in water from a supposedly low trophic status reservoir (Broken Bow) as compared to Lake Tenkiller which Cooke and Welch claim is highly productive due to phosphorus inputs. A Mann-Whitney U non-parametric statistical test confirmed that the two data sets are different ($p < 0.001$). Median TOC data from Lake Tenkiller were lower than median TOC data collected from Broken Bow Reservoir.

The n-values for these two data sets are quite different. There is only one utility, Broken Bow PWA, that draws water from Broken Bow Reservoir, treats it and distributes it to customers. There are 15 water utilities represented in the Lake Tenkiller TOC data set.

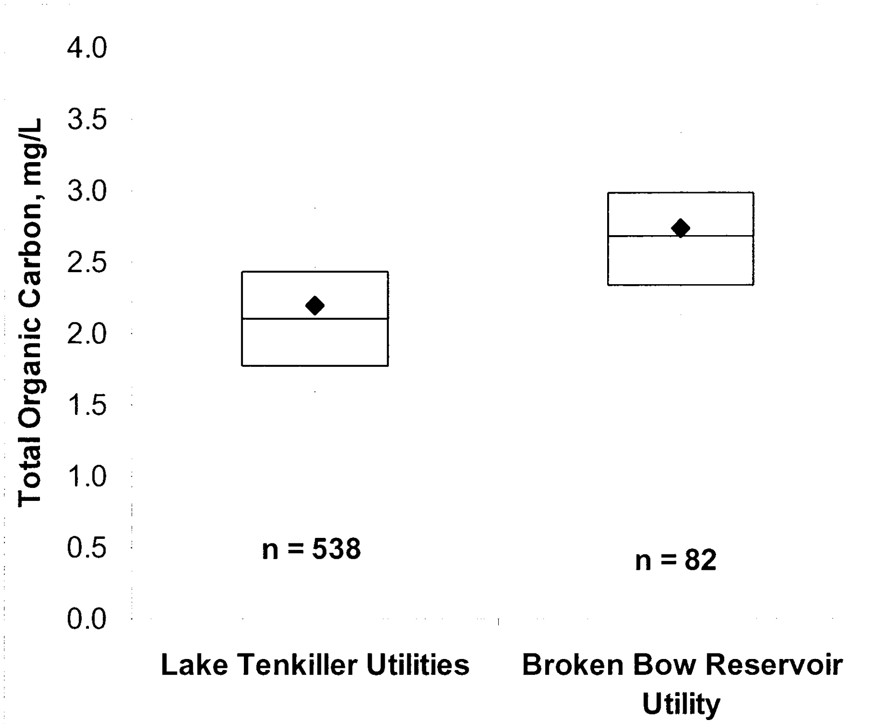

Figure 15. Comparison of Raw Water TOC Values Between Lake Tenkiller and Broken Bow Reservoir (ODEQ 2008a)

One additional data set from a plaintiff expert can be used to compare TOC levels in these two reservoirs. Olsen (2008) presented summarized TOC data for Lake Tenkiller on Table 9 of Appendix C of his report and TOC data for Broken Bow Reservoir on his Table 15 of Appendix C. Once again, there is a lot more data from the Olsen (2008) data set for Lake Tenkiller (n = 293) than Broken Bow Reservoir (n = 4) and comparisons between the two data sets must be interpreted carefully. However, Olsen must have thought that the four TOC values for Broken Bow Reservoir were representative because he included them in his report without any qualifiers. The average TOC values for these two data sets were 2.15 mg/L for Lake Tenkiller and 3.76 mg/L for Broken Bow Reservoir.

A comparison of DBP levels from utilities serving both reservoirs is illuminating. As previously mentioned, Broken Bow PWA is the only community water system that obtains its raw water supply directly from Broken Bow Reservoir, treats that supply and distributes the water to customers (retail and wholesale). Figures 16 and 17 compare the TTHM and HAA5 values from Broken Bow PWA with similar data from Lake Tenkiller water utilities. The TTHM and HAA5 data from Broken Bow PWA are clearly higher than the data from Lake Tenkiller utilities. A Mann-Whitney U test found that there were significant differences for both TTHM and HAA5 between the two data sets, e.g., Lake Tenkiller and Broken Bow Reservoir ($p < 0.001$). Visual comparison of the data sets confirms the statistical interpretations.

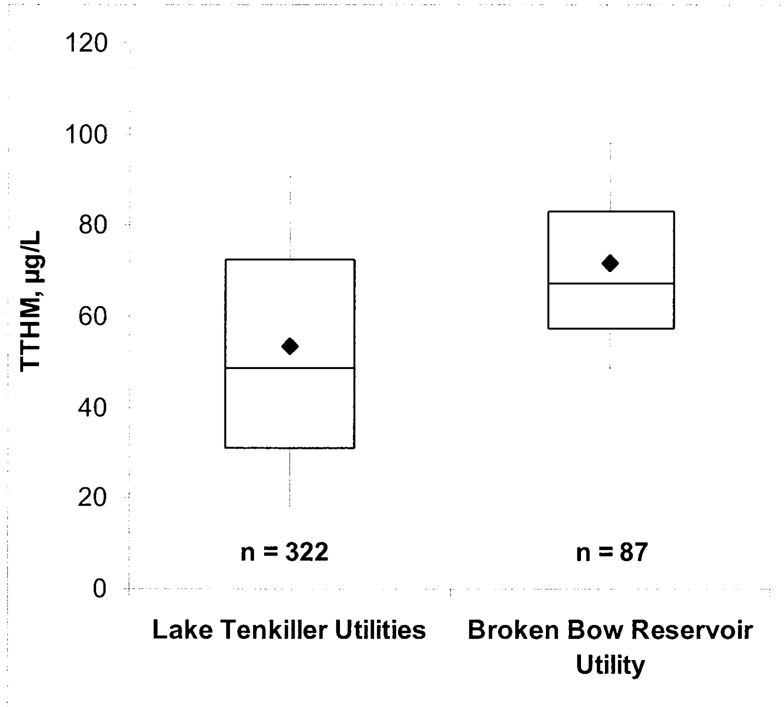

Figure 16. Comparison of Distribution System TTHM Values From Utilities Serving Water From Lake Tenkiller Versus Broken Bow Reservoir (ODEQ 2008a)

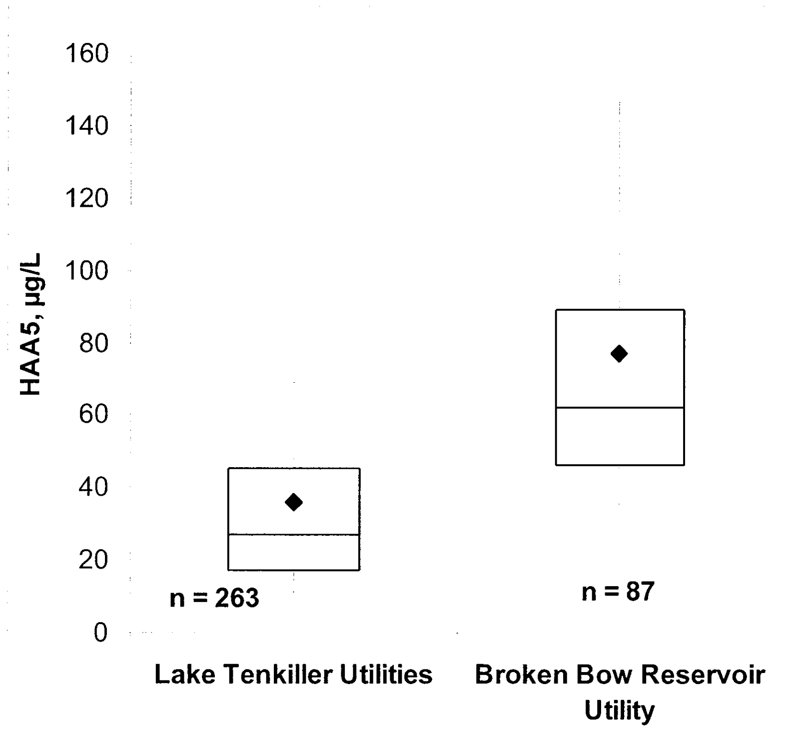

Figure 17. Comparison of Distribution System HAA5 Values From Utilities Serving Water From Lake Tenkiller Versus Broken Bow Reservoir (ODEQ 2008a)

As noted previously in my report, Broken Bow PWA has been in almost continuous violation of the TTHM or HAA5 MCLs between 2002 and 2008.

On page 165 of Dr. Cooke's deposition (Cooke 2008a), he stated:

> "The answer is that what would you expect the quality of drinking water to be from water withdrawn from a reservoir in the Ozark Highlands where all of the water should be oligotrophic or at worst marginally mesotrophic, and the answer is you wouldn't find disinfection byproducts in water like that unless it had become eutrophied."

Water from Broken Bow Reservoir, which Dr. Cooke believes is oligotrophic, clearly contains relatively high levels of TOC and produces significant levels of DBPs after chlorination.

Summary of Cooke and Welch Opinions on DBPs

Therefore, the plaintiffs' expert contentions that lower phosphorus inputs to Broken Bow Reservoir resulted in lower algal productivity and lower THM precursors (as measured by TOC in this example) is not supported by the Cooke and Welch data. The reservoir with the lower trophic status (according to the plaintiffs' experts) actually had higher levels of TOC.

From the Cooke and Welch (2008a) report, page 35: "Tenkiller's watershed has 1,917 active poultry houses, in contrast to 248 in Broken Bow's watershed." Apparently, there is no discernable impact of the higher number of poultry houses on the occurrence of TOC in the two comparable reservoirs. Also, there is no discernable impact of the number of poultry houses on the levels of DBPs in utilities serving drinking water from Lake Tenkiller versus Broken Bow Reservoir. In fact, the watershed with the fewest poultry houses (248 for Broken Bow and 1,917 for IRW, or a factor of 7.7 times lower for Broken Bow) produced the highest TOC levels and the highest levels of DBPs.

Therefore, the comparative trophic status of Lake Tenkiller and Broken Bow Reservoir has nothing to do with either the TOC levels in the two reservoirs or the DBP levels in water served by utilities using these reservoirs. The central thesis of Cooke and Welch (2008a) connecting poultry litter application to DBP levels has been disproved. Attempts by the plaintiffs to contend that more poultry houses in a watershed produced more DBP precursors and higher levels of TTHM and HAA5 in utilities serving that water to customers should not be considered.

Teaf Expert Report—DBPs

In his expert report, Teaf (2008a) stated on page 22,

> "One human health risk associated with the spreading of poultry waste on agricultural fields in large quantities, with associated runoff, is related to the formation of potentially

> carcinogenic substances that may occur in treated drinking water supplies (Cooke and Welch, 2008)."

As demonstrated in the previous section, Cooke and Welch did not demonstrate any association between the spreading of poultry litter and levels of DBPs in tap water.

Sources of DBPs and Organic Matter

On page 23, Teaf (2008a) made the same mistake made by Cooke and Welch (2008a) by attributing all of the organic materials that contributed to the formation of DBPs to runoff from fields where poultry litter had been applied and to the increased productivity of the river and reservoir caused by algae blooms stimulated by higher phosphorus levels. He ignored important sources of organic carbon as noted on Figure 3 in my report that includes natural organic matter from leaves, soil and other naturally occurring organics and the presence of DBP precursors in the organic fraction discharged by wastewater treatment plants.

On page 24, Teaf (2008a) stated, "The formation of DBPs is correlated significantly with the content of dissolved organics in raw water…" Teaf dramatically oversimplifies the role played by TOC in production of DBPs. As already stated in my report, the production of TTHM and HAA5 is based on far more than just the organic material in the water. Figure 18 shows that raw water TOC data from the 296 ICR utilities is NOT correlated with TTHM concentrations in the treatment plant finished water across the U.S. (McGuire and Graziano 2002). The reason for this lack of correlation is important and easy to explain. Those utilities in the U.S. that had high levels of TOC in their sources of supply made treatment changes that mitigated the production of THMs in their distribution systems so that they could comply with the DBP regulation. Also, many of the treatment and distribution systems used by the 500 ICR plants were quite different and produced different DBP levels even if the raw water TOC levels were similar. For example, utilities with relatively low TOC produced high levels of TTHM most likely due to high doses of chlorine and long contact times.

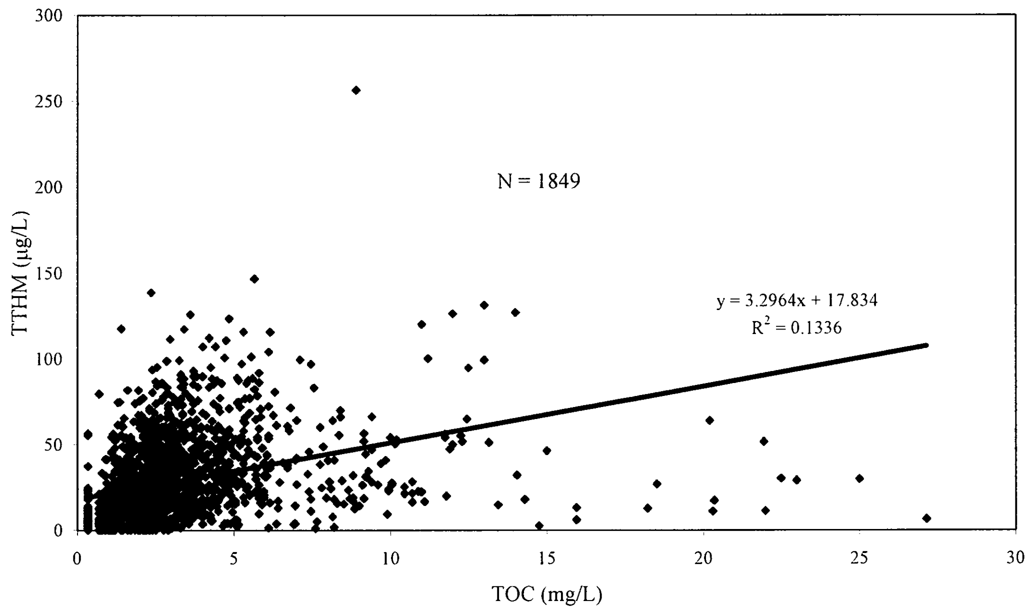

Figure 18. Raw Water TOC Concentrations Versus Finished Water TTHM Concentrations for ICR treatment Plants (McGuire and Graziano 2002)

Later on page 24 of his report, Teaf (2008a) attempts to connect the spreading of poultry litter with high levels of DBPs. As did Cook and Welch, Teaf fails to make the connection using real data from the IRW watershed and utilities treating water from the Illinois River and Lake Tenkiller. Instead he attempts to make the connection citing other studies, which proposed that elevated nutrient inputs were related to DBP production in other watersheds and treatment plants. He strings together a list of suppositions and unsubstantiated statements to try to prove his argument. He failed to prove any connection between the spreading of poultry litter in the IRW and levels of DBPs in water utility distribution systems in the IRW.

Errors Comparing DBP Data with MCLs, MCLGs and Chloroform Risk Based Screening Level

On page 26, Teaf (2008a) gives a synopsis of the Stage 1 and 2 DBP rules. He correctly lists the MCLs and MCLGs for DBPs regulated under the Stage 2 DBPR. However, he then lists "…the following restrictive water concentrations were identified by USEPA (2006c) as being necessary to meet the standard regulatory benchmark of 1-in-one million cancer risk…" Teaf's statement is incorrect. There is no mention of utilities having to meet a one-in-one-million cancer risk in any part of the Stage 1 or Stage 2 DBPRs or supporting documentation. Also, water utilities are not required to comply with the concentrations listed for TTHM and HAA5 MCLGs. MCLGs are goals only.

In Teaf's deposition (Teaf 2008c, page 393), he again identifies the MCLG as a regulatory limit:

> **"Q** I want to go through the columns [Table T1] and clear up a few things for me. I know you've testified about this extensively yesterday and I'm trying not to plow the

same ground. Under chloroform, there are two columns. There's the MCLG of 70 micrograms per liter; right?
A Yes.
Q Excuse me. Is that a regulatory limit?
A For chloroform?
Q Yes, sir.
A Yes.
Q It's a regulatory limit that cannot be exceeded in treated water?
A The MCLG and the MCL in the case of chloroform are equivalent to one another."

As mentioned many times in my expert report, water utilities are required to meet MCLs based on the monitoring requirements and calculation methodologies incorporated in the regulation. Meeting MCLs is the foundation for compliance with primary drinking water regulations under the Safe Drinking Water Act. The MCLG and the MCL in the case of chloroform are absolutely NOT equivalent to one another. Teaf's assertion that utilities must comply with numbers, goals and levels other than MCLs is flatly wrong.

Teaf (2008a) carries his mistake forward when he introduces the "risk-based screening level for chloroform" at 0.17 ppb. He misuses the screening level for chloroform which was developed by the USEPA along with the other (more than 100) screening levels to determine relative risks associated from exposure to environmental contaminants at hazardous waste disposal sites (USEPA 2007a). In other words, the 0.17 ppb risk-based screening level would normally be compared to chloroform levels in residential water that is contaminated with chloroform that resulted from the illegal or uncontrolled disposal of hazardous wastes containing chloroform (along with other chemicals). The 0.17 ppb screening level was never recommended to be compared to chloroform values associated with drinking water chlorination. As stated previously in my report, regulation of THMs (including chloroform) is based on a balancing of risk that includes the benefits associated with elimination of microbial disease by chlorination of drinking water (Murphy and Craun 1999).

On page 34 of the Background document for the screening levels (USEPA 2007a), the USEPA authors stated problems that have been noted in the misuse of the risk-based screening levels:

> "Potential Problems:
> As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of the screening levels table. In order to prevent misuse of screening levels, the following should be avoided:
>
> - Applying screening levels to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios.
> - Not considering background concentrations when choosing screening levels.
> - Use of screening levels as cleanup levels without the consideration of other relevant criteria…" (USEPA 2007a)

The intention of this quoted list of problems is clear, but Teaf (2008a) pays no attention to the limitations embodied in the "Potential Problems" list.

Further, the screening level values were never anticipated to be regulatory limits under any circumstances. Clearly stated on page 2 of the background document is a caution against the improper use of the tabulated values. "The table was not generated to represent action levels or cleanup levels but rather as a technical tool." Teaf ignores this caution and misuses the chloroform 0.17 ppb screening level.

Teaf compounds his lack of understanding of DBP regulatory history and practice when he stated at the bottom of page 27 (Teaf 2008a), "Stated simply, if risks of this magnitude were found at a waste disposal site or an industrial contamination site, in my experience they would require attention and remediation." He betrays his ignorance of drinking water treatment and regulatory compliance by comparing waste disposal site risk analyses with drinking water regulatory practices by the USEPA and state primacy agencies.

The incorrect and non-scientific basis that Teaf used to compare the chloroform risk-based screening level of 0.17 ppb with chloroform concentrations in drinking water served by IRW-based water utilities was improper and should not be considered.

Error Comparing THMFP and TTHM Data

On page 28, Teaf (2008a) discussed THMFP results collected by CDM. Teaf's Table T3 (Teaf 2008a) summarizes the THMFP results from five of the twelve locations sampled by CDM. Teaf states, "...71% of the results (57/80) showed values [of THMFP] in excess of the TTHM MCL at twelve locations along the Illinois River and in Lake Tenkiller." A footnote to Table T3 refers to average THMFP data in the body of the table and states, "*Exceeds EPA drinking water standard of 80 μg/L for Total Trihalomethanes."

Teaf (2008c) stated in his deposition on page 380 in answer to a question:

> "**Q** All right. Now, tell me what does trihalomethane-forming potential tell you about the raw water source sample.
> **A** It tells you the inherent ability of that water to form trihalomethanes upon a **normal** chlorination process." (emphasis added)

It is completely improper for Teaf to compare THMFP values with the TTHM MCL. Such a basic mistake demonstrates a lack of understanding of what THMFP means and how it is used by water quality professionals. The THMFP value is determined by a specific analytical method (APHA 2008). A large dose of chlorine is added to a sample of water so that a chlorine residual of more than 3 mg/L can be detected after seven days at a temperature of 25 degrees C and a pH of 7.0. The chlorine dose could be 6 to 10 mg/L to achieve a greater than 3 mg/L chlorine residual after seven days. These testing conditions do NOT represent a "normal chlorination process." They are designed to accelerate the production of THMs to give an indication of organic and inorganic (bromide) precursor levels in the raw water.

Cooke and Welch (2008a, page 16) also mistakenly compared THMFP with the TTHM standard stating, “All nine utilities had a THMFP in excess of the THM violation standard of 80 μg/L set by the USEPA.”

THMFP is reported as chloroform equivalents. As summarized from APHA (2008), the formula for calculating THMFP as chloroform equivalents is:

$$THMFP = A + 0.728B + 0.574C + 0.472D$$

where:
A = μg /L chloroform
B = μg /L bromodichloromethane
C = μg /L dibromochloromethane
D = μg/L bromoform

As noted, the concentrations of each of the three THMs other than chloroform are converted to an equivalent chloroform concentration by multiplying the analytical concentrations of each by a ratio of the molecular weight of chloroform to the molecular weight of that compound.

TTHM which is used to determine compliance with the MCL is calculated by summing the μg/L concentrations of the four THM components without any conversion to equivalent chloroform concentrations. Therefore, the basis for calculating TTHM and THMFP are completely different and cannot be compared. However, Teaf (2008a) made an even more fundamental mistake when he compared THMFP values with TTHM data collected from a distribution system as part of TTHM regulatory compliance.

On page 35 of a book devoted to DBPs, Xie (2004) stated categorically:

> “Formation potential test [THMFP] is a procedure to evaluate the DBP precursors rather than the formation of DBPs in finished water…However, the **DBP formation potential results cannot be used to estimate the DBP formation under actual chlorination conditions**.” (emphasis added)

THMFP is a measure of the potential for a water sample to form trihalomethanes under extreme chlorination conditions in a laboratory environment. Comparing THMFP values of raw water with the TTHM MCL or levels in a utility distribution system is completely improper and an egregious error. Any conclusions or expert opinions from Teaf that are based on his comparison of THMFP data and the TTHM MCL should be ignored.

Error with OWRB Surface Water Criteria

On page 28 of his report, Teaf (2008a) states:

> “Also found in that criterion is OAC 28 785:45-5-10(5) (B) which states: ‘These waters shall be maintained so that they will not be toxic, carcinogenic, mutagenic, or teratogenic to humans’ (OAC, 2007). The reported TTHM and HAA5s concentrations detected in IRW waters clearly demonstrate that this criterion is not being met.”

Teaf's claim is wrong. If it were true, every drinking water utility in Oklahoma that adds a disinfectant to its water would be in violation of that criterion.

A more careful look at the OWRB surface water criteria (OWRB 2008) shows, on page 13, a requirement to meet numerical criteria to protect beneficial uses of public and private water supplies:

> "**785:45-5-10. Public and private water supplies**
> The following criteria apply to surface waters of the state having the designated beneficial use of Public and Private Water Supplies:
> (1) **Raw water numerical criteria.** For surface water designated as public and private water supplies, the numerical criteria for substances identified under the "Public and Private Water Supply (Raw Water)" column in Table 2 of Appendix G of this Chapter shall not be exceeded."

The introduction to Appendix G states:

> "**APPENDIX G. NUMERICAL CRITERIA TO PROTECT BENEFICIAL USES**
>
> (a) **Introduction.** This Appendix prescribes numerical limits for certain criteria which are necessary to protect beneficial uses as and wherever designated...Table 2 prescribes the numerical limits that cannot be exceeded for certain substances or parameters in order to protect beneficial uses and subcategories as set forth in OAC 785:45-5-10(1), 785:45-5-10(6), 785:45-5-12(f)(6), and 785:45-5-20."

An inspection of their Table 2 in Appendix G shows a long list of organic and inorganic compounds with criteria (and numerical limits), such as benzidine (0.001 mg/L), endrin (0.0002 mg/L), arsenic (0.04 mg/L) and mercury (0.002 mg/L). Chloroform is listed on the table **but there is no numerical limit listed for protection of "Public and Private Water Supply (Raw Water)."** Clearly, if OWRB had intended to protect consumers of drinking water from DBPs they would have included a numerical limit for chloroform which is one of the major components of THMs. They did not include chloroform for the simple reason that neither OWRB general nor specific criteria were intended to address public health protection associated with disinfection byproducts. As an Oklahoma state agency, OWRB is undoubtedly well aware that another State agency, ODEQ, is responsible for regulation of drinking water in Oklahoma to protect public health. The USEPA regulations adopted by ODEQ and already discussed at length in my report provide that regulatory function.

Teaf (2008a) has clearly mischaracterized the intent and actual application of OAC 28 785:45-5-10(5)(B).

Summary of Teaf Opinions

On page 35, Teaf (2008a) summarized his opinion on the risks of DBPs:

> "Increases in nutrients (e.g., phosphorus) related to the land disposal of poultry waste have resulted in eutrophication and increased algal growth broadly in the Illinois River

> Watershed, including Lake Tenkiller. These increased levels of algae and other forms of waterborne organic carbon combine with the normal drinking water disinfection process to produce potentially dangerous Disinfection Byproducts, such as trihalomethanes (THMs) and haloacetic acids (HAA5s). Routine and specific sampling results have identified levels of THMs and HAA5s in drinking water distribution systems that withdraw water from the Illinois River Watershed, and these levels represent an imminent and substantial endangerment to human health."

It is hard to state strongly enough how incorrect and untrue his conclusion is. As stated in my report upon reviewing the data analyses and conclusions by Cooke and Welch and Teaf, these authors made improper comparisons between DBP values in IRW utility systems and DBP "threshold concentrations" that were created by them.

As already demonstrated in a previous section of my report, the levels of TOC in Illinois River and Lake Tenkiller water are not unusual when compared to TOC levels in hundreds of utilities across the U.S. that have had no impact from poultry litter application in their watersheds. Also, the levels of TTHM and HAA5 in IRW water utility systems were not very different from TTHM and HAA5 levels in hundreds of water utilities nationwide.

It is irresponsible for Teaf (2008a) to state that "…these levels [of DBPs] represent an imminent and substantial endangerment to human health." If Teaf was correct, the ODEQ would be forced to issue notices of "do not drink" and "do not use" to consumers of this water. If Teaf was correct and the ODEQ did not take any action, the USEPA would step in and issue a "do not use" advisory to all consumers of water from IRW utilities. Teaf is obviously wrong. Neither ODEQ nor USEPA have issued such advisories. Levels of DBPs produced by IRW utilities do NOT represent an "imminent and substantial endangerment to human health."

King Expert Report—DBPs

Error Understanding DBP Regulations

King (2008a) bases his opinion that remediation of the drinking water treatment plants is needed on his incorrect assessment that the utilities running these plants are violating DBP MCLs at an elevated level—20% to 30%. It appears that most of his information on the health risks associated with DBP occurrence was gleaned from the reports by Cooke and Welch (2008a) and Teaf (2008a). As already demonstrated, neither Cooke and Welch nor Teaf understand how DBPs are regulated or which DBP regulation is currently in force. King illustrates his own lack of understanding regarding DBP regulations on pages 142 and 143 of his deposition when he states that the Stage 2 DBPR is in force (King 2008b).

As explained several times in my report, the Stage 1 DBPR is currently in force and the Stage 2 DBPR will not be effective for systems serving <50,000 people until after 2013. If a utility was in violation of the Stage 1 DBPR, it would have to notify both the ODEQ and its consumers through its annual CCR. King does not understand the regulatory requirements under the Stage 1 and 2 DBPRs and has no basis for concluding that additional treatment is needed.

No Need for Remediation of Water Treatment Plants in the IRW

As stated on page 28-29 of my report, there are three IRW utilities that need to modify their treatment processes to come into compliance with the Stage 1 DBPR (i.e., Cherokee Co RWD #13, East Central OK and Gore PWA). All of the other IRW utilities have successfully installed simple technologies or adjusted existing treatment methods to achieve low DBP levels.

Discontinuation of poultry litter applications on fields in the IRW will have no effect on the ability of these three utilities to comply with the Stage 1 or Stage 2 DBPRs. These three utilities must install better TOC removal and move their points of chlorination just as the other utilities in the IRW have done to control the existing, background levels of TOC in the IRW water supplies. Therefore, there is no needed remediation of water treatment plants associated with poultry litter applications in the IRW.

Error with Treatment Costs for Water Treatment Plants in the IRW

King (2008a) includes in his list of IRW utilities, Cherokee County RWD #11. This utility purchases treated water from Tahlequah PWA. King was wrong to include Cherokee County RWD #11 in his analysis. As a water system purchasing treated water from Tahlequah PWA, Cherokee County RWD #11 would not incur any costs to modify treatment of that water source because they are NOT providing any treatment of the Tahlequah purchased water. Cherokee County RWD #11 has another water source that it does treat and distribute to its customers—Double Spring Creek, which is outside of the IRW. Double Spring Creek is a tributary to Fort Gibson Lake which is a watershed adjacent to the IRW. Therefore, none of his so-called remediation costs for Cherokee County RWD #11 should ever be considered in this lawsuit.

On page 30 of the King (2008a) report, he stated that treatment would be required at the five "Riverine" water treatment facilities:

> "*Costs* — Costs of this technology were estimated based on US EPA published estimates provided as part of the Federal Register when the disinfection byproduct rule was promulgated (FR Vol 71, No. 2, January 4, 2006 p. 456). Costs were escalated from 2003 dollars to 2008 dollars using the Engineering News-Record Construction Cost Index History. Four water treatment plants (WTPs) used the Illinois River for source water while one WTP used Baron Fork Creek. Capital costs for all five WTPs were estimated at a total of $220 million; annual costs were estimated to be $19 million in aggregate; and the total present worth cost over 30 years for this technology was estimated at **$452 million**." (emphasis added)

For the fourteen utilities using water from Lake Tenkiller, King (2008a) stated on page 31 his opinion on the need for additional treatment at those water treatment plants:

> "*Costs* —Costs of this technology were estimated based on US EPA published estimates provided as part of the Federal Register when the disinfection byproduct rule was promulgated (FR Vol 71, No. 2, January 4, 2006 p. 456). Costs were escalated from 2003 dollars to 2008 dollars using the Engineering News-Record Construction Cost Index

> History. Fourteen water treatment plants (WTPs) use Lake Tenkiller for source water. Capital costs for all fourteen WTPs were estimated at a total of $233 million; annual costs were estimated to be $28 million in aggregate; and the total present worth cost over 30 years for this technology was estimated at **$583 million**." (emphasis added)

Therefore, according to King, the total present worth (over 30 years) for treatment upgrades to the riverine and lake water treatment facilities would be $1,035 million. Spending over one billion dollars to install water treatment plant upgrades to control DBPs in 19 (actually 18) relatively small water treatment plants is incredibly expensive and way out of line with other Stage 1 and Stage 2 DBP regulation compliance costs. According to the ODEQ SDWIS web site, 48,820 people are served by the 19 (should be 18) IRW water utilities. That means that the 30 year net present value would be $21,200 per person which is an astonishing number and far above what was predicted for compliance costs for U.S. water utilities under the Stage 2 DBPR (USEPA 2006). The following section explores the mistake that King made to come up with his cost estimate.

As noted in the above quotes from King (2008a), he obtained his treatment costs from page 456 of the January 4, 2006, *Federal Register,* which contained the final Stage 2 DPBR. Table 11 reproduces the portion of Table VI.D-7 from page 456 that King referenced and used in his calculations (USEPA 2006).

Table 11. Capital and O&M Costs for Utilities to Comply with the Stage 2 DBPR, millions of dollars (page 456, USEPA 2006)

Source	System Classification	System Size (population served)	Capital Costs				O&M Costs			
			Mean Value	Median Value	90 Percent Confidence Bound		Mean Value	Median Value	90 Percent Confidence Bound	
					Lower (5th %tile)	Upper (95th %tile)			Lower (5th %tile)	Upper (95th %tile)
Surface Water	CWSs	<100	$ 1.09	$ 1.07	$ 0.58	$ 1.68	$ 0.20	$ 0.20	$ 0.11	$ 0.29
		100-499	$ 3.27	$ 3.22	$ 1.77	$ 4.94	$ 0.82	$ 0.82	$ 0.46	$ 1.19
		500-999	$ 3.86	$ 3.78	$ 2.08	$ 5.89	$ 0.6	$ 0.61	$ 0.34	$ 0.88
		1,000-3,299	$ 24.39	$ 24.27	$ 13.37	$ 36.07	$ 3.36	$ 3.36	$ 1.88	$ 4.86
		3,300-9,999	$ 62.23	$ 61.92	$ 34.42	$ 91.81	$ 5.32	$ 5.34	$ 2.97	$ 7.70
		10,000-49,999	$ 113.20	$ 113.98	$ 62.72	$ 157.05	$ 6.04	$ 6.00	$ 3.74	$ 8.66
		50,000-99,999	$ 67.40	$ 68.08	$ 37.41	$ 93.50	$ 3.41	$ 3.36	$ 2.13	$ 4.95
		100,000-999,999	$ 183.98	$ 186.24	$ 98.21	$ 257.75	$ 8.17	$ 7.87	$ 5.21	$ 12.52
		1,000,000+	$ 86.04	$ 86.46	$ 47.14	$ 120.41	$ 4.91	$ 4.65	$ 3.11	$ 7.73
		All Sizes	$ 545.44	$ 549.03	$ 297.70	$ 769.10	$ 32.84	$ 32.21	$ 19.95	$ 48.78

Tables 7 and 8 from the King (2008a) report summarized his cost calculations for the riverine and lake water utilities, respectively. I will use Adair Co RWD #5 as an example to show his calculations. From the table on page 456 of the *Federal Register*, King selected a median "unit" compliance cost for a utility serving surface water to 500-999 people of $3.78 million in capital costs and $0.61 million in annual O&M costs (both values circled in red on Table 11). He then multiplied both numbers by 1.2085 which he claimed accounted for the increase in the *Engineering News-Record* construction cost escalation between 2003 and 2008. Multiplying an O&M cost by a construction cost escalation factor is a problem in itself, but there were far more serious mistakes made by King.

After his cost escalation adjustment for the Adair Co RWD #5 example, he arrived at a "unit" capital cost of $4.57 million and a "unit" O&M cost of $0.74 million. **"Unit" costs in this context means the cost to install or operate treatment to meet the Stage 2 DBPR in *ONE* treatment plant.** These values can be found on Table 7 in his report. The problem with his calculation is that the costs he took off of the table on page 456 of the *Federal Register* were NOT "unit" costs. These costs were the ***ENTIRE NATIONAL COMPLIANCE COSTS*** for utilities across the U.S. that fell into that population category. In other words, the capital costs for ALL community water systems in the U.S. using surface water in the population-served range of 500 to 999 people was estimated by the USEPA to cost $3.78 million (value circled in red on my Table 11). This is a mistake by King of such immense magnitude that it is difficult for me to describe or for the reader of my report to appreciate.

So there is no misunderstanding the size of the mistake made by King, the reader will note that on Table VI.D-7 on page 465 of the *Federal Register* (USEPA 2006) that the **TOTAL CAPITAL COST FOR THE STAGE 2 DBPR FOR THE ENTIRE U.S. was estimated to be $842.98 million**. The total capital costs presented by King were **$453 million** for 18 small treatment plants. The document referenced in the footnote to Table VI.D-7 on page 465 of the *Federal Register* details how the numbers on the table were determined (USEPA 2005a). On page 7-27 of the referenced document (USEPA 2005a) are the two tables that contained the **unit treatment costs** for different population categories—7.10a Capital Unit Costs ($/Plant) for CWS Surface Water Plants and 7.10b Annual O&M Unit Costs ($/Plant/Year) for CWS Surface Water Plants.

Appendix J (USEPA 2005b) of the cost document contains the same table as shown on page 456 of the *Federal Register*. In Appendix J, the title of the table is specific: Exhibit J.1a Total Stage 2 DBPR Capital and O&M Costs – PWSs.

We can get some insight into how King could have made such an incredible mistake by reviewing his deposition. On pages 199 to 200 of his deposition (King 2008b), the following question and answer exchanges took place:

> "Q Okay. The EPA document that you're referring to is a Federal Register, Volume 71, No. 2, January 4, 2006. It's referenced on Page 30 of your report.
> A Yep.
> Q Okay. Who told you to use that section?

A Jana (sic) Skadsen found that for me.
Q What's Jana's background?
A She's a water treatment plant operator, retired from the City of Ann Arbor and currently works for us [CDM].
. . .
Q Okay. Did you have to perform any calculations with respect to the information contained in the Federal Register, Volume 71, Number 2?
A I believe I read directly off the table and multiplied it by the number of users.
Q Okay.
A Or, actually I might have taken the number of users and then just plugged in the number.
THE REPORTER: I'm sorry.
Q Okay.
A Looked at the number of users for a particular plant and read the associated costs as part of the area capital output volume.
Q Okay. And you were provided with a number of users of each of those plants?
A Yes, sir.
Q Where did you get that information?
A Boy, I don't recall. That should be in the e-mail records, though."

King was obviously not familiar with the DBP regulation in the *Federal Register* and asked Janice Skadsen on the CDM staff to pull out the relevant cost information. Because he did not know what the table on page 456 meant, he mistakenly assumed that the numbers on the table were **unit costs** instead of **national compliance costs**. Regardless of how he made the mistake, his cost calculations are totally wrong and should not be considered for any purpose.

Even if King had not made the incredible calculation mistakes detailed in this section of my report, any costs that he came up with would have been irrelevant. As stated previously in my report as part of my rebuttal of the Cooke and Welch (2008a) and Teaf (2008a) reports, there is no need to cure "human health concerns" associated with DBPs in water served by IRW water utilities taking water from the Illinois River or Lake Tenkiller. Therefore, there are no costs because no injury has been demonstrated by Cooke and Welch, Teaf or King.

Mistake with Population Categories

As an important footnote to the mistakes King (2008a) made in calculating costs, King used the wrong population cost categories from the table on page 456 of the Federal Register in four cases. Table 12 lists all 19 of the utilities for which he evaluated costs and identified the populations served for each based on data from the ODEQ. In the adjoining column is the population category that he used in miscalculating the compliance costs for IRW utilities. Four of the utilities were miscategorized according to their populations served. Obviously, there was no quality control exercised over King's calculation method, his data source or his water utility populations served.

Table 12. Population Categories Used by King and Associated Errors

Water Utility Name	Population Served*, a	Population Category Used by King From p. 456 FR
Adair Co RWD 5	950	500-999
Burnt Cabin RWD	118	100-499
Cherokee CO 2 (Keys)	1,239	1,000-3,299
Cherokee CO 11	3,088	3,300-9,999
Chrokee CO RWD 13	2,120	1,000-3,299
East Central OK	1,200	1,000-3,299
Fin Feather Resort	150	100-499
Flint Ridge RWD	1,300	1,000-3,299
GORE PWA	1,688	1,000-3,299
LRED (Chicken Creek)	302	100-499
LRED (Lakewood)	250	100-499
LRED (Wildcat)	250	100-499
LRED (Woodhaven)	200	100-499
Pettit MT Water	90	100-499
Sequoyah Co RWD 5	1,075	1,000-3,299
Sequoyah County Water Asso	15,719	50,000-99,999
Tahlequah PWA	18,431	50,000-99,999
Tenkiller Aqua Park	150	100-499
Tenkiller Utility Co	500	500-999
Total	48,820	

*Source: ODEQ SDWIS web site, http://sdwis.deq.state.ok.us/index.jsp
a Includes retail and wholesale population served
Note: Shaded cells indicate an incorrect population range chosen by King

McGuire Expert Opinion #1--DBPs

It is my opinion, based on a reasonable degree of scientific certainty, that application of poultry litter to fields in the IRW has no discernable impact on the levels of total organic carbon in IRW waters. The production of trihalomethanes and haloacetic acids in water served by utilities providing drinking water from Lake Tenkiller and the Illinois River cannot be linked to the application of poultry litter in the IRW. The only DBP MCL compliance problems in the IRW are associated with three utilities (out of 18) and are caused by ineffective design or operation of their treatment facilities and not poultry litter. It is also my opinion that there is no imminent and substantial endangerment to human health associated with disinfection by-products in drinking water served by IRW utilities.

BASIS OF EXPERT OPINION #2—TASTE AND ODOR

Taste and Odor Regulation in Drinking Water

At the federal level, there is a secondary standard for odor in water which is expressed as a secondary maximum contaminant level (SMCL) of "3 threshold odor number." The definition and use of "threshold odor number" (TON) will be explored later in my report. As stated in the Code of Federal Regulations regarding SMCLs:

> "These levels represent reasonable goals for drinking water quality. The States may establish higher or lower levels which may be appropriate dependent upon local conditions such as unavailability of alternate source waters or other compelling factors, provided that public health and welfare are not adversely affected. [44 FR 42198, July 19, 1979, as amended at 51 FR 11412, Apr. 2, 1986; 56 FR 3597, Jan. 30, 1991]" (USEPA 2007b)

The State of Oklahoma has adopted the secondary standard for odor in drinking water along with the other SMCLs by reference:

> "252:631-1-3. Adoption of U.S. EPA regulations by reference. The provisions of ...143, "National Secondary Drinking Water Regulations," of Title 40 of the Code of Federal Regulations (CFR) as published on July 1, 2007, and the requirements contained therein are, unless otherwise specified, adopted and incorporated by reference..." (ODEQ 2008c)

An on-line fact sheet published by ODEQ clearly states the position of secondary standards in the regulatory structure affecting drinking water utilities in Oklahoma.

> "The U.S. Environmental Protection Agency (EPA) sets standards for public drinking water supplies. (Primary drinking water standards are health-related and are legally enforceable. Public water supplies must comply with primary standards.) Secondary drinking water standards affect the quality of the water in terms of aesthetics such as color and odor, but do not cause human health effects. A secondary drinking water standard is a suggested level above which the water may have a color or odor that may be objectionable, but will not cause adverse health effects." (ODEQ undated)

Regulations adopted by the Oklahoma Water Resources Board dealing with tastes and odors in drinking water are addressed in a later section where the Cooke and Welch (2008a) taste and odor claims are examined.

Besides secondary standards, there is a long history of investigations into the sources and causes of tastes and odors in drinking water.

History of Taste and Odor Investigations

Whipple (1899) and Baylis (1935) are two early books which explored where tastes and odors originate in water supplies, how to measure the character and intensity of tastes and odors and what treatment systems are available to mitigate objectionable tastes and odors in finished drinking water.

Since those early publications, much progress has been made in our collective understanding of what causes tastes and odors in drinking water and what means can be used to control aesthetic problems. As mentioned in the Education, Experience and Qualifications section of my report, from 1979 to 1990 at Metropolitan, I created and implemented the most comprehensive taste and odor identification and control program for any water utility in the U.S. at that time. Innovation and research to improve T&O tools was necessary at Metropolitan because the most significant T&O problem in 40 years appeared in a major water supply reservoir in 1979. Significant earthy-musty odor problems in Lake Mathews resulted in many thousands of complaints throughout Southern California.

The only tool that was in general use in 1979 to monitor T&O problems was TON. The TON method is based on the dilution of a sample with odor-free water until an odor is not perceptible by an analyst's sense of smell. In 1979, I found that, while TON gave some useful information on the overall problem, it was not possible to track the earthy-musty T&O problem to its source. I directed the development of the first analytical method to measure the two compounds (geosmin and 2-methylisoborneol or MIB) most responsible for earthy-musty odors at part-per-trillion (or ng/L) concentrations (McGuire et al. 1981). We used the closed-loop stripping analysis (CLSA) method to isolate the MIB problem in Lake Mathews to a benthic (attached or bottom growing) cyanobacterium called *Oscillitoria curviceps*. This method is still included in *Standard Methods* and is being used by water utilities. The CLSA we developed has seen significant improvements and a SPME-based analytical method is now offered by contract laboratories to determine the identity and concentration of organic compounds causing T&O problems.

In the early 1980s, the Metropolitan research team was able to identify the cyanobacteria producing geosmin and MIB and causing the T&O problems in reservoirs (Izaguirre et al. 1982; Izaguirre et al. 1983). We also developed reservoir management and reservoir control technologies during this period to mitigate earthy-musty T&O problems (McGuire et al. 1983; McGuire et al. 1984).

In addition to an instrumental method to detect T&O problems, I needed a human-based analytical procedure at Metropolitan to quickly isolate and identify taste and odor problems when the identity of the organic compound was not know. In the early 1980s, the Metropolitan laboratory adapted the Flavor Profile Analysis (FPA) method from the food and flavor industry to analyze drinking water samples (Krasner, McGuire and Ferguson 1984). FPA panels are currently in use by water utilities and research organizations throughout the U.S. and the FPA method is included in *Standard Methods* (APHA 2008).

A T&O assessment tool that was used by me after my work at Metropolitan was the employment of consumer panels to determine off flavors in drinking water. Consumer panels are comprised of untrained members of the public. Samples are presented to panel members and questions are asked of them to solve specific problems regarding the taste and odor characteristics of individual compounds and mixtures of compounds. Under my direction, consumer panels have been used to determine the level of minerals (total dissolved solids) in water that were acceptable to consumers, evaluate the odor threshold for methyl *tert* butyl ether, and evaluate changes in sources of supply and blends of different water qualities. (Aciukewicz et al. 1999; Stocking et al. 2001; McGuire et al. 2007)

The professional literature contains hundreds of papers describing treatment methods that can be used to remove T&O problems at water treatment plants (Mallevialle and Suffet 1986; Suffet, Mallevialle and Kawczynski 1995). I have reviewed those methods as well as directed and conducted research on a variety of technologies that have successfully removed earthy-musty problem odors as well as other T&O compounds (Lalezary, Pirbazari, and McGuire 1986a; Lalezary, Pirbazari, and McGuire 1986b; McGuire and Gaston 1988; Ferguson et al. 1990).

Finally, I published a comprehensive evaluation method that utilities could use to solve T&O problems. The assessment tool created by the AWWARF-sponsored project is available to any water utility that is interested in understanding and controlling tastes and odors in their systems (McGuire et al. 2004; McGuire, Hund and Burlingame 2005).

The purpose of this section of my report was not to present a comprehensive review of the hundreds to thousands of publications detailing how T&O problems can be identified and controlled. Many researchers have been engaged in these studies for over 100 years. Instead, this section has shown that there are many tools available to water utilities and water professionals who are truly interested in understanding how to identify and control T&O problems in drinking water.

Cooke and Welch Expert Report—Taste and Odor

On page 2 of the Cooke and Welch (2008a) expert report, they stated:

> "The switch to eutrophic-hypereutrophic trophic states in Tenkiller produced major changes in water quality. These changes presently endanger human health and the environment. There were shoreline scums of algae and reduced water clarity, especially in upper reservoir areas. Dominant algae became bluegreens (Cyanobacteria), which were associated with disinfection by-products, **tastes, and odors in treated tap water**, and produced a human liver toxin (microcystin) found in Tenkiller in 2003... Objectionable **tastes and odors** appeared in some Tenkiller tap water." (emphasis added)

The purpose of this section of my report is to demonstrate conclusively that there is no evidence of significant taste and odor problems in Lake Tenkiller.

On page 17 of the Cooke and Welch (2008a) report, it is stated:

> "Utility operators who withdraw water from Tenkiller indicated that **they often increase the chlorine dose** in an attempt to offset tastes and odors in tap water (telephone interviews between operators and HSWMR Inc). While this treatment may be effective in oxidizing taste and odor molecules, increased chlorine and chlorine contact time in the plant and distribution system will lead to increased THMs in the tap water (El-Dib and Ali, 1994; Graham et al. 1998)." (emphasis added)

The impression that the reader gets in this quote is that it is a common occurrence for water utility operators to increase chlorine dosages. Cooke and Welch are vague as to how widespread chlorine increases are practiced. Actually, only two of the 20 utilities mentioned in their interviews that they increased chlorine as a result of tastes and odors. (HSWMR 2006)

Of the 20 utilities contacted, 15 utilities did not mention any taste and odor problems. Which means, of course, that only 5 of the 20 utilities contacted made any mention of taste and odor problems (HSWMR 2006). When depositions were taken of selected IRW utilities, two utilities in addition to the five in the survey mentioned minor taste and odor events (e.g., Gore PWA, Tenkiller Utility Co). (Lindley 2008; Connor 2008) If there were significant taste and odor problems in the IRW, all 20 utilities would have reported customer complaints.

Oklahoma Water Quality Standards

On page 18 of Cooke and Welch (2008a), they stated:

> "These complaints indicate a direct violation of Oklahoma Water Quality Standards under 'General Narrative Criteria: Taste and Odor' (OAC 785:45-5-9) and Oklahoma's aesthetic water quality standard which states: 'The water must be free from noxious odors and tastes (OAC 785:45-5-19).'"

Noxious is a powerful word and has a clear meaning. One set of definitions of noxious includes: "1. physically harmful: harmful to life or health, especially by being poisonous, 2. morally harmful…, 3. disgusting: very unpleasant—a noxious smell" (MSN Encarta 2008)

No experienced taste and odor professional can read the narratives of the conversations with the 20 water utility operators and conclude that the tastes and odors that they were describing were anywhere close to "disgusting."

Under "PART 3. BENEFICIAL USES AND CRITERIA TO PROTECT USES, 785:45-5-9. General narrative criteria," the full text of OAC 785:45-5-9 is:

> "(c) **Taste and Odor.** Taste and odor producing substances from other than natural origin shall not interfere with the production of a potable water supply by modern treatment methods or produce abnormal flavors, colors, tastes and odors in fish flesh or other edible wildlife, or result in offensive odors in the vicinity of the water, or otherwise impair any beneficial use." (OWRB 2008)

No reasonable person could read the narratives of interviews with water utilities and determine that the beneficial use criterion of taste and odor is violated as stated by Cooke and Welch. These authors have not produced any data that proves that the relatively minor taste and odor concerns voiced by the operators interfered with production of potable water. No evidence has been presented by the plaintiffs' experts that potable water deliveries were discontinued due to taste and odor problems. Also, there have been no data presented that fish flesh or edible wildlife has been contaminated. Nor has there been any testimony or data presented that offensive odors have been detected in the vicinity of the water.

Cyanobacteria and Taste and Odor

On page 18 of the Cooke and Welch (2008a) report is stated, "The appearance of taste and odor molecules in tap water is linked directly to increased nutrient concentrations, especially P, that stimulate an increase in algal biomass." Cooke and Welch make this statement without data to support it. As found in Lakes Mathews and Skinner in Southern California, MIB and geosmin were produced in these reservoirs by benthic cyanobacteria that had nothing to do with phosphorus levels in the bulk water. Benthic cyanobacteria get all the nutrients they need from the sediments that they are growing on (Taylor et al. 2006). Using Scuba, I have personally observed benthic growths of *O. curviceps* on sediments in Lakes Mathews and Skinner. Based on our investigations, the growth of this organism and other benthic cyanobacteria in the reservoirs was stimulated from decomposing organic matter that was feeding these benthic growths with a sufficient supply of nutrients.

Later on page 18, Cooke and Welch (2008a) state:

> "Algae associated with taste and odor episodes are found among the blue-greens, diatoms, dinoflagellates, and greens. Prediction of a taste and odor problem from a species list is difficult because the synthesis of these compounds appears to be confined to specific strains of various species. The presence of a "bloom" of any of the following algae genera is a warning signal to a water supply utility that they may need to begin additional treatments to remove taste and odor."

The authors are correct that a variety of algae can produce taste and odor problems. Cooke and Welch state that it is "difficult" to predict a possible taste and odor episode from an algae species list. Based on my extensive taste and odor experience, it is not only difficult; it is impossible to do so.

Just because cyanobacteria were present in Lake Tenkiller does not mean that there were taste and odor problems. As stated by Taylor et al. (2006):

> "It is common practice to ascribe a taste and odor problem to an organism that happens to be abundant at the time; many of the T&O algae in the older literature were determined in this way. However, this approach is not always valid. Concurrence does not necessarily prove causation."

Cooke and Welch then state that a bloom of any of the genera they list is a warning signal that a utility may have to start treatment process to remove taste and odor. This claim is not true. Algae bloom for a variety of reasons and the resulting bloom may have no impacts on the T&O characteristics of the water. It would be a waste of time and money for utilities to use an algae bloom based on the genera they list to institute taste and odor treatment measures. As stated previously in this section, other tools are available which can definitively identify a taste and odor event in a reservoir. FPA and analysis for the causative compound (geosmin and MIB if it is an earthy-musty problem) are far more effective than starting an expensive treatment process based on the presence of a certain algal genus. Publications of early warning systems based on effective monitoring tools have specified the needed steps to identify and control taste and odor episodes (McGuire et al. 1983; Taylor et al. 2006).

On page 19, Cooke and Welch (2008a) list a number of studies that purportedly show some relation between trophic status and taste and odor. While the authors of the other studies were able to show these relationships that does not mean that the relationships hold for Lake Tenkiller. In fact, Cooke and Welch have never shown any data in Lake Tenkiller where nutrient input and trophic status is related to taste and odor problems because they have not demonstrated that taste and odor is a problem in this reservoir.

Finally, Cooke and Welch (2008a) on page 20 make an additional, unfounded statement: "Tenkiller had ideal conditions for taste and odor episodes throughout the 10 summers investigated between 1986 and 2007 (see Section C, Reservoir Trophic State)." In their opinion, these conditions existed over 10 summers. However, the water treatment professionals who are responsible for treating and serving water to their customers did not say in the interviews that taste and odor problems existed over the entire 10 summer period or if they did have taste and odor complaints during the 10 summers it is clear that these problems were relatively minor.

On page 25, Cooke and Welch (2008a) state: "Among the beneficial uses impaired by high TP concentrations are public and private water supply (DBPs, tastes and odors, algal toxins)..." The taste and odor evidence in this section of my report rebutting Cooke and Welch's arguments has demonstrated that public and private water supply beneficial use has not been impaired.

Cooke and Welch have failed to show that a significant taste and odor problem exists now or has ever existed in Lake Tenkiller.

Teaf Expert Report—Taste and Odor

On page 7, Teaf (2008a) repeats the untrue taste and odor claims made in the Cooke and Welch (2008a) report:

> "The eutrophic conditions have bred and continue to breed blue-green algae which, in addition to causing nuisance tastes, odors, and toxins in potable water, contribute to the production of potentially carcinogenic disinfection by-products during the treatment process of potable water supplies."

Teaf (2008a) provides no new data or any other support for the unsubstantiated taste and odor claims made by Cooke and Welch (2008a).

Dr. Teaf claims in his report and in his deposition that there are taste and odor problems in water served by IRW utilities. As mentioned previously, only 5 of the 20 utilities surveyed by the plaintiffs' consultants mentioned any concerns with taste and odor in the water they were serving (HSWMR 2006). Two of the complaints cited by utilities were related to a chlorinous odor. Chlorine is added by all 18 IRW utilities for disinfection purposes and is a common taste and odor complaint of water utility customers throughout the U.S. (Disinfection Systems Committee 2008)

Teaf (2008a) also claims on page 28 of his report that IRW water does not meet "Oklahoma narrative standards for water supplies" (OAC 785:45-5-9 and 785:45-5-19). As demonstrated in the critique of the Cooke and Welch report regarding taste and odor issues, these claims are not true.

On page 32, Teaf (2008a) claims that "The presence of cyanobacteria also can cause taste/odor problems from a number of chemicals they release, such as geosmin and methylisoborneol..." While it is **possible** that this can occur, Teaf (like Cooke and Welch) has not demonstrated that cyanobacteria in Lake Tenkiller have produced **one molecule** of geosmin or MIB. Just saying that it can happen does not mean that it does happen.

In Dr. Teaf's report (Teaf 2008a, page 28), he claims that there are taste and odor problems in water served by IRW utilities and that those problems are caused by the concentrations of trihalomethanes and haloacetic acids in these water supplies.

> "Beyond the increased human health risks, elevated levels of THMs and HAA5s in drinking water often result in esthetic concerns (e.g., disagreeable taste and odors) in water supplies at concentrations which are at or near the drinking water standards (USEPA, 2006c)."

In his deposition (page 416 beginning on line 16), Teaf (2008c) states in response to a question:

> "Q All right. You have not tracked the number of complaints as far as time or from where in the systems the complaints came from; correct?
> A We have not. We have this information and we have the trihalomethane concentrations, which we know are well in the range of taste and odor detection.
> Q Now, what can cause taste and odor perceived by a consumer of a public water system; what are the potential causes?
> A Well, there are several, and they include trihalomethanes. That in my experience is the most common... but my experience, once again, is that the majority of taste and odor complaints are related to trihalomethanes in most water supplies."

No publication in the drinking water literature or the vast literature on taste and odor has ever shown or even suggested that levels of THMs and HAA5 produced in drinking water cause taste and odor problems. Dr. Teaf is wrong.

Table 13 is a compilation of threshold odor concentrations for available data on the four THMs. None of these threshold odor concentrations are exceeded in water served by IRW water utilities. No one has tested the odor threshold concentrations (OTCs) or taste threshold concentrations (TTCs) for the HAAs because they are low molecular weight acids that are highly soluble in water and are extremely unlikely to be detectable at concentrations normally found in water.

Table 13. Odor and Taste Thresholds for DBPs in Water

Compounds	OTC, ppb	TTC, ppb
TTHM		
Chloroform	100[a]; 1,000[b]; 7,500[c]	1,200[b,c]
Bromodichloromethane	40[d]	NA
Dibromochloromethane	50[d]	NA
Bromoform	300[a]	NA
HAA5		
Monochloroacetic acid	NA	NA
Dichloroacetic acid	NA	NA
Trichloroacetic acid	NA	NA
Monodibromoacetic acid	NA	NA
Dibromoacetic acid	NA	NA

Notes: OTC = Odor Threshold Concentration; TTC = Taste Threshold Concentration; NA - Not Available

[a]Grunt et al. 1977; OTC in water at 60 deg C

[b]Alexander et al. 1982; TTC in water at 40 deg C

[c]Young et al. 1996; TTC in water at 25 deg C

[d]Khiari et al. 2002

Dr. Teaf makes an astonishing error in citing the Stage 2 DBP Rule published in the Federal Register as a source for his claim that levels of THMs and HAA5 in water served by IRW utilities result in disagreeable tastes and odors. The only place in the entire Stage 2 DBP Rule document where the phrase "taste and odor" or the individual words "taste" or "odor" appear is on page 446 in the sub-section labeled "Nonquantified Benefits" where it states:

> "To the extent that the Stage 2 DBPR changes perceptions of the health risks associated with drinking water and improves taste and odor…" (USEPA 2006)

This sentence clearly refers to the nonquantified benefits of the Stage 2 DBP Rule that would result from the installation of advanced treatment technologies such as ozone and granular activated carbon to control DBPs that can also improve the aesthetic characteristics of drinking water. In fact, two sentences below the above quote, the regulation stated:

> "Also, as PWSs move away from conventional treatment to more advanced technologies, other nonhealth benefits are anticipated besides better tasting and smelling water." (USEPA 2006)

THMs and HAAs do not cause taste and odor problems in drinking water. Teaf has failed to demonstrate that a significant taste and odor problem exists now or has ever existed in Lake Tenkiller.

Taste and Odor Investigations that Should Have Been Conducted

Cooke and Welch and Teaf have failed to demonstrate that a significant taste and odor problem exists in Lake Tenkiller. The reason is that no definitive studies were conducted. Twenty telephone calls were made. The results of those 20 telephone calls did not show a significant problem.

If Cooke and Welch and Teaf were serious about investigating taste and odor occurrence in Lake Tenkiller they should have collected a few hundred samples, at multiple locations and depths in the lake over a minimum of one year and subjected those samples to the following analyses:

- Closed-loop stripping analysis or SPME analysis for MIB and geosmin
- Flavor profile analysis by a professionally trained panel
- Consumer panel determination on a subset of the FPA samples

The cyanobacteria identified and enumerated in surface water samples should have been isolated in cultures and subjected to FPA analysis to determine if any of them were odor producers. Odorous cultures should then have been analyzed by Sensory Gas Chromatography (Sensory GC) to identify the odorous compounds (Suffet, Mallevialle and Kawczynski 1995).

Cooke and Welch and Teaf should have also used Scuba divers to collect benthic algae samples from representative locations on the lake bottom over a year period and determine if any odorous benthic algae were present. They should have then grown cultures of odorous algae (if any were present) and identified the compounds producing the odors by Sensory GC followed by Mass Spectrometry.

Threshold odor number should have been determined on finished water samples for the 18 water utilities over several years to see if any elevated odor events were linked to seasonal changes in the reservoir.

Only by identifying the source of any taste and odor problems (planktonic or benthic), identifying the problem algae and then determining any odorous problem compounds can a cost-effective T&O control strategy be determined. Geosmin and MIB are tertiary alcohols that cannot be oxidized by chlorine or chlorine dioxide. Ozone, UV/H_2O_2 and PEROXONE are effective oxidation treatment methods for these earthy-musty odorants (Dani, Linden and

Summers 2007; Ferguson et al. 1990; Lalezary, Pirbazari and McGuire 1986a). GAC and PAC can be used to remove geosmin and MIB (Lalezary, Pirbazari and McGuire 1986b). Determination of the concentrations of these compounds that cause taste and odor problems at the ng/L level is necessary to set doses of oxidants and carbon.

On the other hand, organic compounds causing fishy, swampy and grassy odors are easily oxidized by chlorine and no extraordinary treatment is required.

At a minimum, the 18 water utilities should have been maintaining detailed complaint logs over several years. Cooke and Welch and Teaf would then have been able to analyze those logs for trends to determine if any patterns of taste and odor problems existed.

Only after such a source water, treatment and complaint T&O assessment would the authors be able to state definitely that there was a significant taste and odor problem in Lake Tenkiller. The methods described above comprise the state-of-the-art of taste and odor investigations and should have been used to conduct such an assessment.

King Expert Report—Taste and Odor

King states on page 4 of his report (King 2008a):

> "The State's experts have identified several injuries that are related to land disposal of poultry waste. These injuries are categorized as (1) Human Health impacts; (2) Tenkiller Ferry Lake (Lake Tenkiller) impacts; and (3) Rivers and Streams impacts. The preliminary injuries to be addressed by remediation are:
>
> <u>Human Concerns and Health Issues</u>
>
> .....
>
> - Taste and odor of drinking water
>
> <u>Lake Tenkiller</u>
>
> .....
>
> - Taste and odor (public water supplies)"

As detailed in the previous section of my report, neither Cooke and Welch nor Teaf have demonstrated any "injuries" related to taste and odor in drinking water because they have failed to prove that any significant taste and odor problems exist in Lake Tenkiller or in utilities serving water from the IRW.

In the rest of his report, King does not identify or provide costs for any remedial actions that would address the supposed "injuries" associated with tastes and odors in drinking water. Apparently, any "injuries" that King thought there might be with respect to T&O were not serious enough to assign remediation costs to them.

McGuire Expert Opinion #2—Taste and Odor

Based upon a reasonable degree of scientific certainty, it is my opinion that the evidence and opinions presented by plaintiffs' experts do not establish that there are significant taste and odor problems in the Illinois River Watershed, including Lake Tenkiller. Poultry litter cannot be considered the source of problems that have not been proven.

BASIS OF EXPERT OPINION #3—CYANOTOXINS

Microcystin LR (microcystin) and other cyanotoxins fall into the category of emerging contaminants that are under study by a number of researchers and regulatory agencies around the world. As stated previously in my report, the only drinking water regulations that Oklahoma water utilities are required to meet are those established by the USEPA under the SDWA or regulations established by the State of Oklahoma. This section of my report examines the fact that cyanotoxins are not regulated by either the USEPA or Oklahoma. Opinions expressed by Cooke and Welch and Teaf in their expert reports are not based on any official determination of regulatory policy and must be viewed with proper skepticism.

Cyanotoxins on Contaminant Candidate Lists

The USEPA is required by the Safe Drinking Water Act to perform regulatory determinations on a periodic basis, in which at least 5 contaminants are considered for regulation. The USEPA prepares CCLs "to prioritize research and data collection efforts to help [them] determine whether [they] should regulate a specific contaminant". CCL 1 was published in March 1998 with 60 contaminants; CCL 2 in February 2005 with 51 contaminants; and CCL 3 was released as a draft in February 2008 with 93 chemicals/groups and 11 microbiological contaminants. The USEPA evaluates the drinking water occurrence of contaminants in the CCLs, treatment technologies, whether regulation would offer a "meaningful opportunity" for public health risk reduction, and the availability of analytical methods for measuring the contaminants.

"Cyanobacteria (blue-green algae), other freshwater algae, and their toxins" were listed in the CCL 1 and CCL 2 under the Microbial Contaminant category. The Draft CCL 3 does not list cyanobacteria or algae, but rather lists cyanotoxins, followed by the statement that "various studies suggest three cyanotoxins for consideration: Anatoxin-a, Microcystin-LR, and Cylindrospermopsin". After CCL 1 and CCL 2, the USEPA concluded that they did not have sufficient information on cyanotoxins "to support regulatory decisions at this time." No cyanotoxin analytical methods have been standardized by the USEPA, and a national database on cyanobacteria occurrence is not available (USEPA 2008). However, cyanotoxins were brought forward into the CCL 3 and the USEPA has funded studies to fill some of the data gaps surrounding cyanotoxins.

Cyanotoxins and the Unregulated Contaminant Monitoring Rule

Before a regulatory decision can be made for any of the chemicals listed on a CCL, occurrence data must be generated. The Unregulated Contaminant Monitoring Rule (UCMR) is used to determine occurrence information for specific contaminants cited on the CCLs. Some of the contaminants listed on CCL 1 in 1998 were evaluated using the1999 UCMR. The 1999 UCMR included 3 monitoring options: Assessment Monitoring for which all large systems (approximately 2,800 systems) and 800 small systems were required to monitor for specified contaminants for 1 year; Screening Survey for which only a select group of large and small water systems were required to conduct monitoring; and Pre-Screen Testing which targeted vulnerable water systems to gain information on contaminant occurrence in systems with the greatest likelihood of having detectable levels of a contaminant using new analytical methods. None of the 1998 CCL 1 microorganisms, including cyanobacteria, had methods in 1999 that could be used for UCMR Assessment Monitoring.

In 2001, a panel of scientists with expertise in the area of fresh water algae and their toxins convened at the USEPA Technical Center in Cincinnati, Ohio to assist the Office of Ground Water and Drinking Water in identifying a target list of algal toxins that were likely to pose health risks in source and finished drinking water in the United States (USEPA 2001). The algal toxins, selected by the panel and the USEPA, were to be monitored under the UCMR Pre-Screen Testing component when standardized and validated methods became available. If significant occurrence of a specific cyanotoxin is found during Pre-Screen Testing, the contaminant could be monitored in a later screening survey or assessment monitoring. Information obtained on the occurrence of these toxins, through one or more UCMR surveys, would form the basis for regulatory determinations about algal toxins in drinking water.

The panel established priority categories for several of the cyanotoxins. Three cyanotoxins were considered the highest priority. These include microcystin, anatoxin-a, and cylindrospermopsin (in order of priority, Nicholson et al. 2007). These are the same cyanotoxins cited in the Draft CCL3 in 2008. A summary of cyanotoxin classifications established by the panel is provided in Table 14 below.

Table 14. Prioritization of Algal Toxins According to a USEPA-Convened Technical Panel (USEPA 2001)

Highest Priority	Medium Priority	Further Study Needed	Not a Drinking Water Issue at This Time*
• Microcystin • Cylindrospermopsin • Anatoxin-a	• Saxitoxin • Anatoxin-a(s)	• Nodularin • Lyngbyatoxin • Aplysiatoxin • Debromoaplysiatoxin • Prymnesin • Domoic acid	• LPS Endotoxin

Algal Toxin Regulatory or Guideline Values

No algal toxin regulatory or health-based guidelines have been established by the USEPA, for reasons discussed above. The World Health Organization has developed a drinking water provisional guidance value for Microcystin-LR of 1.0 µg/L, but stated that other cyanobacterial toxins do not have sufficient data to establish similar guidelines (WHO 2003). The guidance value is "provisional" because it only includes Microcystin-LR and toxicity information is not complete. WHO's Guidelines for Drinking-water Quality are kept up-to-date by a "rolling revision" process, where relevant updates related to cyanotoxin research are incorporated as addendums. The most recent guideline values are included in the third volume of the WHO Guidelines for Drinking-water Quality published in 2003. The fourth volume is currently in draft form.

Other countries have guidance or regulatory values for cyanotoxins. Table 15 summarizes drinking water guidance values (and one regulatory value) as noted in the report from the 2001 USEPA UCMR convention on cyanotoxins in Cincinnati, Ohio (USEPA 2001) and by Burch (2008). Most of the countries followed WHO's lead in establishing guidance values for microcystin. Brazil took the further step of setting a regulatory value of 1.0 µg/L.

Additionally, Australia has suggested guidance values of 3.0 µg/L and a range of 1.0 -15 µg/L for Anatoxin-a and Cylindrospermopsin, respectively. Cylindrospermopsin is included in the plan of work for the rolling revisions of the WHO Guidelines for Drinking-water Quality. The Guidelines for Drinking-water Quality Final Task Force meeting (WHO 2003) recommended that a background document on Cylindrospermopsin be prepared.

Table 15. Domestic and International Guidelines for a Select Group of Cyanobacteria Toxins (USEPA 2001; Burch 2008)

Location	**Microcystin-LR**	**Anatoxin-a**	**Cylindrospermopsin**
USA	-	-	-
Oregon	1.0 µg/L	-	-
WHO	1.0 µg/L	-	-
Brazil	1.0 µg/L (regulatory)	-	-
Australia	1.3 µg/L (total microcystins*)	3.0 µg/L (suggested)	15 µg/L (suggested)
New Zealand	1.0 µg/L	-	-
Canada	1.5 µg/L	-	-
Czech Republic	1.0 µg/L	-	-
France	1.0 µg/L	-	-
Japan	1.0 µg/L	-	-
Poland	1.0 µg/L	-	-
Spain	1.0 µg/L	-	-

* Expressed as toxicity equivalents of Microcystin-LR.

Cyanotoxin Occurrence

The most recent and comprehensive survey of cyanotoxins in U.S. waters was conducted by the U.S. Geological Survey (USGS) in 2007. Between May and October 2007, the USGS analyzed samples from 1150 lakes, reservoirs, and ponds for microcystin as part of the USEPA's National Lake Assessment. Preliminary results showed microcystin present in approximately 32 % of the samples at average and median concentrations of 3 µg/L and 0.5 µg/L, respectively (Loftin et al. 2008). Figure 19 shows that while microcystin has been identified in a large number of lakes throughout the U.S. (particularly in the upper Midwest) there are no detections in the northeastern area of Oklahoma (the area where Lake Tenkiller is located).

No evidence has been presented by plaintiffs' experts that application of poultry litter caused high microcystin concentrations in the U.S. lakes noted on Figure 19.

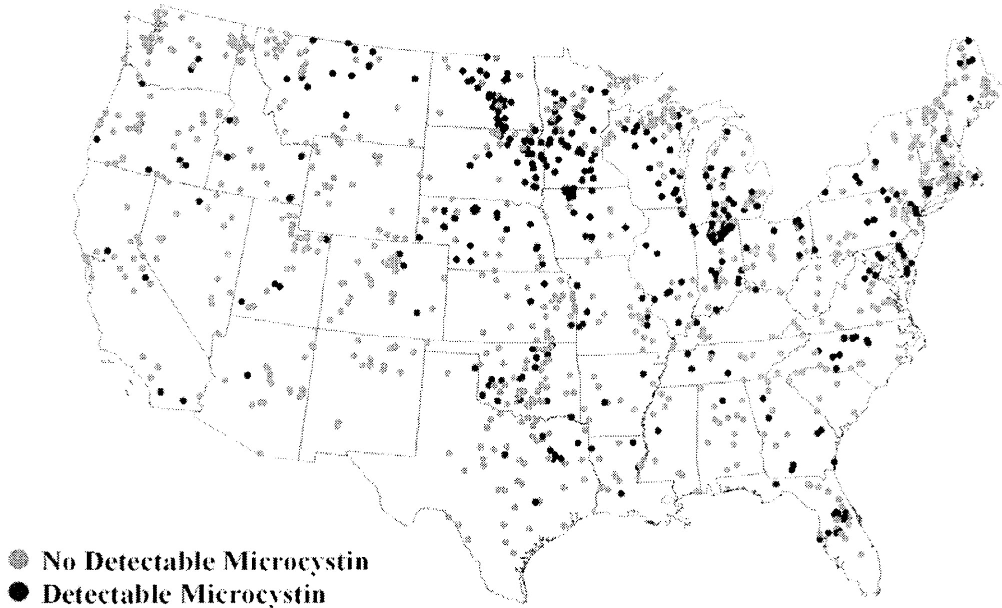

Figure 19. Microcystin Distribution in U.S. Lakes (Loftin et al. 2008)

Cooke and Welch Expert Report--Cyanotoxins

On page 32, Cooke and Welch (2008a) state:

> "Microcystin was detected at two of five sites in Tenkiller in July, 2005 (Lynch and Clyde 2006). The concentration at one site was 0.35 µg/L, whereas the second site had a concentration of 3.3 µg/L. The higher MC [microcystin] concentration, while above the WHO guideline of 1.0 µg/L, is considered a low risk concentration for human liver cancer (WHO 1999). **No tap water determinations of algal toxins at Tenkiller were made.** CDM sampled Tenkiller near three potable water intakes (Cherokee #2 and #13, Gore PWA) on three dates during summer 2007. No microcystin was found." (emphasis added, references are cited in Cooke and Welch 2008a)

Therefore, monitoring conducted by plaintiffs' consultants and cited by Cooke and Welch (2008a) found extremely limited occurrence of microcystin in Lake Tenkiller. Tap water was not even sampled. As noted in Figure 19, the occurrence of microcystin in U.S. lakes is not unusual. Levels far above those cited by Cooke and Welch exist as natural byproducts of cyanobacteria metabolism across the U.S. Cooke and Welch have not tied the limited determinations of microcystin in Lake Tenkiller to any activities in the IRW. All of their conclusions and opinions related to the occurrence of microcystin are based on supposition and the work of other investigators in different watersheds and water bodies.

On page 32, Cooke and Welch (2008a) state:

> "A final major concern regarding Cyanobacteria toxins in Tenkiller involves potable water treatment. Numerous studies (e.g. Yoo et al. 1995; Stone and Bress 2007; Pitois et al. 2001) found that conventional raw water treatment (coagulation, sedimentation, filtration, chlorination) is ineffective at MC [microcystin] removal."

Actually, Yoo et al. (1995) reported exactly the opposite of what Cooke and Welch reported. Yoo et al. (1995) found that chlorination was effective in destroying cyanotoxins. On page 152 of their report, Yoo et al. stated:

> "In contrast to these earlier findings, recent Australian work (Nicholson et al. 1994) showed that chlorination of the hepatotoxins, microcystin-LR and Nodularin, was very effective at destroying the toxins provided that a free chlorine residual of 0.5 mg/L was achieved following 30 minutes contact time. Experiments showed that toxin removal efficiency was pH dependent, with effective destruction occurring at below pH 8."

Later on page 156:

> "Some of the negative findings on chlorination involved either inadequate doses to achieve the necessary free chlorine residuals or chlorination was performed at higher pH."

Cooke and Welch have chosen to only cite those references which they claim support their point of view or they misrepresent what authors have published in the citations that they used. There are numerous studies that show effective removal (inactivation) of microcystin using conventional water treatment. For example, Karner et al. (2001) studied microcystin removal in 5 full-scale conventional water treatment plants. They found that conventional treatment (including pre-oxidation) removed raw water microcystin by factors of 10 to 1,000 to well below 1 μg/L.

Chlorination by itself has been shown to specifically inactivate microcystin. Figure 20 shows significant microcystin removal at a pH level typical of waters in the IRW. Lower pH levels resulted in more effective removal of microcystin by chlorine. In the conclusion to their presentation, the authors stated, "Extracellular microcystin-LR was effectively inactivated by free chlorine." (Xagoraraki and Harrington 2004) This work has also been published in a peer-reviewed article (Xagoraraki et al. 2006).

As demonstrated in my report, the relatively high levels of chlorine and the contact time available in IRW water treatment plants is more than sufficient to effect significant removals of microcystin in IRW raw waters should this compound or its related compounds ever consistently appear.

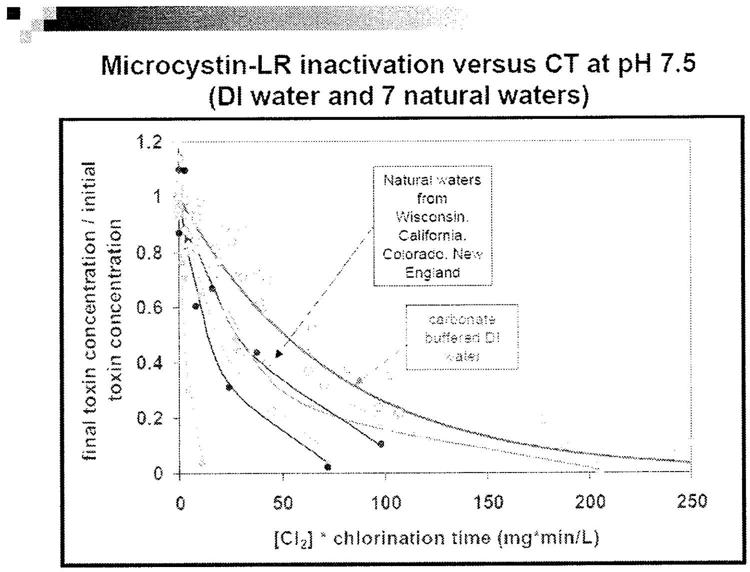

Figure 20. Inactivation of Microcystin LR by Chlorine (Xagoraraki and Harrington 2004)

Cooke and Welch have not demonstrated that the phosphorus levels in Lake Tenkiller are responsible for concentrations of cyanotoxins in the lake. Just because cyanobacteria **can** produce high levels of cyanotoxins **does not** mean that cyanobacteria **do** produce high levels of cyanotoxins in Lake Tenkiller. In addition, Cooke and Welch have ignored evidence that chlorination and conventional water treatment processes remove (inactivate) significant concentrations of cyanotoxins in raw water supplies. Therefore, Cooke and Welch have not proven any links between application of poultry litter to fields in the IRW, significant concentrations of cyanotoxins in Lake Tenkiller and harmful levels of cyanotoxins in tap water served by IRW utilities.

On page 25, Cooke and Welch (2008a) state: "Among the beneficial uses impaired by high TP concentrations are public and private water supply (DBPs, tastes and odors, algal toxins)…" The cyanotoxin evidence in this section of my report rebutting Cooke and Welch's arguments has established that the impairment of public and private water supply beneficial use has not been demonstrated by Cooke and Welch.

Teaf Expert Report--Cyanotoxins

On page 35, Teaf (2008a) states a summary of his opinion on cyanotoxins"

> "Increases in nutrients (e.g., phosphorus) related to the land disposal of poultry waste have resulted in eutrophication and increased algal growth broadly in the Illinois River Watershed, including Lake Tenkiller. Among the measures of increased eutrophication is the detection of potentially dangerous levels of Cyanobacteria, also termed "Harmful Blue Green Algae". The levels of Cyanobacteria reported in a number of studies

> conducted within Lake Tenkiller represent an imminent and substantial endangerment to human health."

First of all, all cyanobacteria are NOT "Harmful Blue Green Algae." Many genera and species of cyanobacteria are innocuous. It is improper and incorrect for Teaf to claim that all blue-green algae are harmful. Secondly, I have shown in my rebuttal of the cyanotoxin opinion by Cooke and Welch (2008a) that **only two values for microcystin have ever been determined in Lake Tenkiller**. I have also demonstrated that cyanotoxins are found in lakes across the U.S. caused by cyanobacteria growths that have nothing to do with application of poultry litter in watersheds. I have also demonstrated that conventional treatment processes, especially chlorination, remove cyanotoxins from raw water supplies.

It is incorrect for Teaf (2008a) to state that "The levels of Cyanobacteria reported in a number of studies conducted within Lake Tenkiller represent an imminent and substantial endangerment to human health." If Teaf was correct, the ODEQ would be forced to issue notices to consumers of this water to not drink it and to not use it in cooking. If Teaf was correct and the ODEQ did not take any action, the USEPA would step in and issue a "Do Not Use" advisory to all consumers of water from IRW utilities. Teaf is obviously wrong. Neither ODEQ nor USEPA have issued such advisories.

Cyanotoxin Data from IRW and Other Lakes in Oklahoma

A defendants' expert has addressed the issue of cyanotoxins in Lake Tenkiller. In his expert report, Gibb (2008) on page 23 stated:

"In summary, cyanobacterial cell density, microcystin levels, and chlorophyll-a concentrations in Lake Tenkiller are similar to those found in lakes in Oklahoma that are not in the IRW. In fact, there are lakes in Oklahoma and the rest of the U.S. with considerably more cyanobacteria problems than Lake Tenkiller. Microcystin concentrations in Lake Tenkiller indicate that there is a low probability of health effects per the WHO guidelines. The State of Oklahoma has issued no press releases or epidemiology bulletins on cyanobacteria. Although there have been reports of cyanobacteria-related illness in states other than Oklahoma (e.g., 22 cases in Nebraska in 2004 (Dziuban et al. 2006)), the CDC has not reported any outbreaks of cyanobacteria-related illness in Oklahoma for the last 10 years."

McGuire Expert Opinion #3--Cyanotoxins

It is my opinion, based upon a reasonable degree of scientific certainty, that the plaintiffs' experts have not demonstrated any link between the two low level concentrations of microcystin found in Lake Tenkiller with poultry litter use in the IRW. It is also my opinion that there is no imminent and substantial endangerment to human health associated with cyanotoxins in drinking water served by IRW utilities.

BASIS OF EXPERT OPINION #4—RESIDENTIAL WELLS

The purpose of this section of my report is to critique information on the nitrogen levels reported in residential wells by plaintiffs' experts and assess their claims regarding sources of nitrogen in residential wells and remediation needs associated with nitrogen compounds, especially nitrate.

Nitrate in U.S. Groundwater

Under the SDWA, nitrate is regulated as an acute health risk with an MCL of 10 mg/L as N. Nitrate is found throughout the U.S. in both surface waters and groundwaters as a result of natural processes and discharges of wastes, especially as a result of contamination of private wells by private septic tanks in rural areas.

Figure 21 shows the geographic distribution of groundwater nitrate concentrations in the U.S. from a recent USGS study (Nolan and Hitt 2006). Elevated nitrate levels are found across the U.S. especially in areas of intensive agriculture—California central valley, Texas and the upper Midwest. The levels in the IRW are not substantially different from other areas in the country. The other areas of the country with equivalent levels of nitrate or higher levels have not been demonstrated to be under the influence of poultry litter applied to fields.

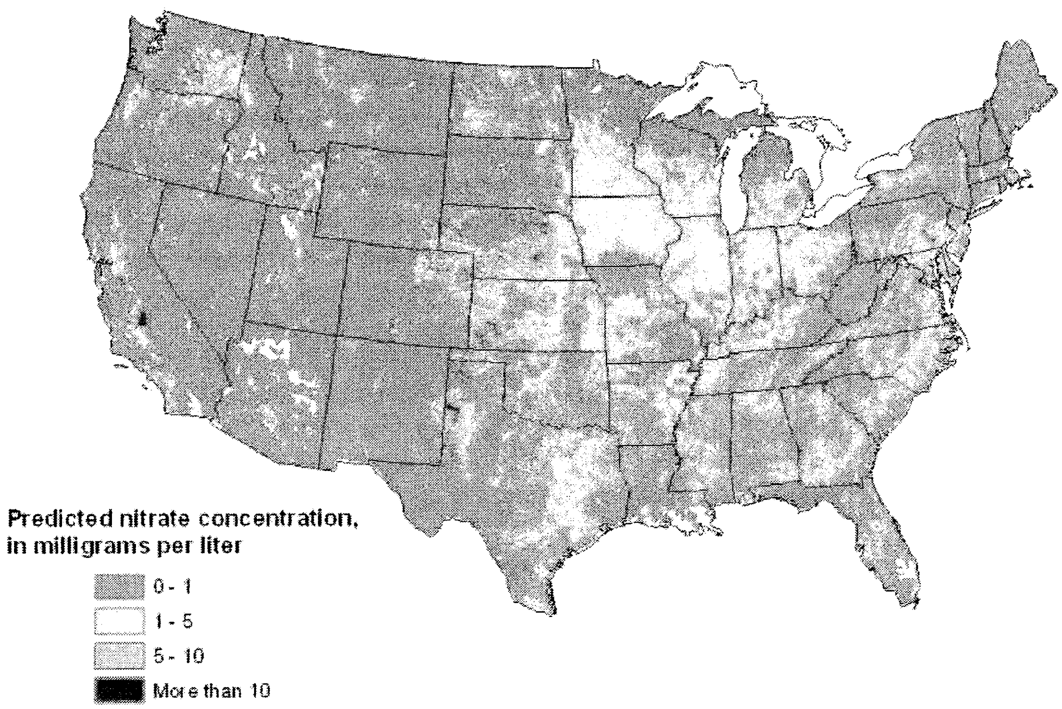

Figure 21. Predicted Nitrate Concentrations in U.S. Groundwater (Nolan and Hitt 2006)

Plaintiffs' Expert Reports—Nitrate in Residential Wells

Tables 12, 13 and 14 in Appendix C of Olsen (2008) contain summaries of the data collected by CDM from geoprobe, groundwater and spring samples. The only connection that Olsen attempts to make between the nitrogen in poultry litter to concentrations of nitrate in groundwater is contained in his Principal Component Analysis discussion.

Larson, on page 26 of his expert report (Larson 2008), disputes Olsen's conclusion using the PC scores:

> "However, Olsen's PC score determinations are discussed below to show that the analysis is not a reliable indicator of impacts to groundwater and, even if they were, they are inconsistent with the assumptions made by King regarding groundwater impacts related to poultry litter."

King (2008b) stated on page 161 of his deposition:

> "Q But if poultry litter is not the source, then the remedial options discussed in your report, would they need to be implemented or not?
> A They are directed at poultry waste.
> Q Okay. So if poultry litter is not the source, then your remedial options are not needed?
> MR. BLAKEMORE: Object to the form.
> A I guess I'm having a hard time trying to -- if it's not the source, yeah, I guess I'd agree."

Later on pages 213-214, King (2008b) admitted that he did not know the sources of the nitrate in groundwater:

> "Q All right. Just so I'm clear, your position is that the injury that needs to be addressed in the Illinois River Watershed that derives in nitrogen or nitrogen compounds comes from the ingestion of water containing nitrates?
> A Yes, sir.
> Q Now, as to your three constituents of concern; phosphorus, bacteria and nitrogen, total nitrogen; have you traced the injury back to any source site for any one of these constituents of concern?
> A Me personally, no."

Nitrate contamination of private wells by private septic tanks in rural areas is not uncommon. Larson (2008) on page 3 of his expert report provided statistics on septic tank failures, particularly in the IRW:

> "Septic tanks, which are used by over 76,000 residents in the Illinois River watershed, are a significant source of localized groundwater contamination. Septic tanks are a source of nitrate and bacteria to groundwater. The failure rate for septic tank systems within the Illinois River watershed is significant. The Illinois River Basin Plan indicates that it is likely that as many as 75% of the on-site waste disposal systems are inadequately constructed or located (Haraughty, 1999). A survey of septic systems in Tontitown and

> Highfill, Arkansas, indicated that 74 out of 171 septic tank systems (43%) had some type of reported failure (Engineering Services, Inc., 2004). The rate of failure indicated by these studies is much higher than the 8% failure rate assumed by plaintiff consultant Teaf."

In Gibb's expert report (Gibb 2008) on page 24, he provided additional data on high nitrate levels in rural areas and criticized King's claims:

> "90. Drinking water MCLs apply to public water systems, not to the private wells sampled by CDM. Furthermore, 8 of 60 wells (13%) with concentrations above the MCL for nitrate is not unusual for private wells in agricultural areas. Ward et al. (2005) reported that about 22% of domestic wells in agricultural areas of the United States contain nitrate levels that exceed the MCL. About 10% of Wisconsin's 800,000 private wells have nitrate-nitrogen concentrations exceeding the MCL, and in agricultural areas the percent exceeding the MCL is between 17% and 26%. In one agricultural area in Wisconsin (Stevens Point), the percent of wells with nitrate exceeding the MCL was reported to be over 60%. Fifty-four of the 1,000 wells (5.4%) used by schools, churches and businesses on an everyday basis in Wisconsin were reported to have nitrate levels greater than the MCL (The Nutrient Management Subcommittee of the Nonpoint Source Pollution Abatement Program Redesign 1999). A survey of private well-water users in Iowa found that 35% of wells less than 50 feet deep had nitrate levels exceeding the MCL (Kross et al. 1993).
>
> 91. In summary, Mr. King has made no claims of health effects occurring in the IRW as a result of nitrate in drinking water. The MCL for nitrate applies to public water systems, not to the private wells for which Mr. King claims that the MCL is exceeded. In contrast to the CDM data cited by Mr. King, the USGS found no evidence of a nitrate problem in wells in the IRW in the 1992-1995 time period. Regardless, nitrate occurrence in agricultural areas is not uncommon. It is estimated that 22% of domestic wells in agricultural areas of the U.S. exceed the MCL for nitrate compared to the 13% which Mr. King claims exceed the MCL in the IRW based on CDM data."

Larson (2008) (page 28) found that no defensible connections could be made between poultry litter and nitrate in groundwater wells:

> "In general, the PC analysis presented by Olsen gives the misleading impression that most of the groundwater within the Illinois River Basin has been adversely affected, either by poultry litter and/or by waste water treatment plant effluent, and cannot be used for drinking water supply. The actual sampling data do not support this impression. For the most part, the groundwater quality as represented by the samples collected by the plaintiff consultants meets USEPA drinking water standards. Exceptions to this generalization include a limited number of samples where the 10 mg/L nitrate standard is exceeded and the occurrence of total coliform and fecal coliform. As discussed previously, the limited number of nitrate exceedances is not predominately related to poultry litter according to Olsen's own analysis and this frequency of exceedance is not uncommon for the types of land use in the basin."

Residential Well Remediation Claims

On page 7 of his report, King (2008a) stated:

> "The remedial action objective for N is to treat or replace all impacted private drinking wells within the State of Oklahoma that pose a risk to human health. CDM estimated that 190 drinking water wells are potentially impacted within the Oklahoma portion of IRW for N. This is based on an estimated 1463 groundwater wells within the IRW for Oklahoma and the finding that 8 of 60 private wells sampled by CDM in 2006 and 2007 were reported with **total nitrogen results greater than 10 mg N per liter**. The oxidation of N to nitrate at concentrations greater than 10 mg N per liter exceeds the maximum contaminant level for nitrate under the National Primary Drinking Water Regulations promulgated by the U.S. Environmental Protection Agency." (emphasis added)

There are several problems with King's statement. First of all, King's estimate of private wells that need to be replaced is based on 8 of 60 wells sampled only once by CDM in 2006 and 2007. It is inconceivable to me that a professional would claim a need for remediation of wells based on such a small sampling. King admitted in his deposition (King 2008b) that more data was needed before large expenditures of funds could be considered. In his deposition (King 2008b, page 207-208), King admitted that he only had limited data to come up with his estimate that 190 wells should be replaced due to nitrogen problems.

> "Q Okay. How can you make that recommendation given the fact that you have only sampled 60 wells?
> A I think the recommendation is based on the best available data that I had at the time I put together the report.
> Q You would prefer if you were going to recommend the replacement of a well, that that well actually be tested, wouldn't you?
> A You could certainly improve upon the basis for the estimate that I provided herein, but this is the first preliminary roll up and **based on a limited -- admittedly limited dataset**, we made some projections." (emphasis added)

The second problem with his statement is that he did not determine the number of wells that needed remediation (190) based on the number of wells (8 out of 60) that exceeded the nitrate MCL. He made his determination on the number of wells that exceeded a **total nitrogen value of 10 mg/L as N**. He assumed that there would be "oxidation of N to nitrate." Larson (2008) in his expert report stated that he could only find 5 of the 60 wells that exceeded the nitrate value of 10 mg/L as N. It is difficult for me to express how incorrect it is to assume that all of the total nitrogen in a sample would somehow be oxidized to nitrate. No peer-reviewed journal would accept such an assumption in an article presented to them for review.

McGuire Expert Opinion #4—Residential Wells

It is my opinion, based upon a reasonable degree of scientific certainty, that no connection has been made by the plaintiffs' experts between nitrate as a result of field application of poultry litter and nitrate concentrations in residential wells in the IRW and that no remediation of residential wells is necessary.

BASIS OF EXPERT OPINION #5—SAFETY OF DRINKING WATER SERVED BY IRW UTILITIES

In his deposition (Teaf 2008b, pages 30-31), Dr. Teaf responded to the following question:

> "**Q** Okay. Is it safe to drink the water in the IRW, the treated water?
> **A** I think that there are systems where that's questionable, and it's questionable on a long-term basis, for which we have very little data. Most of the data that we have is post 2003 or '4, and a good bit of it is post 2006 as a result of the implementation of the Stage 2 Disinfection Byproducts Rule at the federal level."

Dr. Teaf erred in his answer by stating that there is very little data on which to base a judgment which he then makes by stating that the safety of the treated water in the IRW is questionable. There is a substantial amount of data available on the IRW utilities, which are listed on the ODEQ web site (ODEQ 2008a). The data has been sufficient for ODEQ to continue to allow these utilities to operate and serve water to their customers.

In his expert report on pages 35-36, Dr. Teaf made a far more negative statement regarding the safety of the drinking water being served in the IRW. (Teaf 2008a)

> "The hazards and impairments [bacteria and indicator organisms, THMs/HAA5s, cyanobacteria] represent an imminent and substantial endangerment to human health."

Either Dr. Teaf modified his opinion between when he wrote his report and when he gave his deposition or he forgot how definitive his statement was in his report. In my opinion, it is unconscionable and irresponsible for any scientist or engineer to state that water supplies "represent an imminent and substantial endangerment to human health" without proof to back up such a statement. ***Making such an irresponsible statement is the public health equivalent of shouting "fire" in a crowded theater when there is no fire.***

Dr. Teaf's statement is false on the face of it. If the water utilities in the IRW were serving water that "represented an imminent and substantial endangerment to human health," the ODEQ would be forced to step in and warn all consumers not to use the water, stop the delivery of drinking water by the utilities and take over the utilities and place them in the hands of other operators. If ODEQ did not take such action in such a dire situation, the USEPA would step in to do so.

As stated before, Dr. Teaf repeatedly misrepresents drinking water regulatory requirements. In the above quote from his deposition, he made an error by stating that the Stage 2 DBP Rule has been implemented. "Most of the data that we have is post 2003 or '4, and a good bit of it is post 2006 as a result of the implementation of the Stage 2 Disinfection Byproducts Rule at the federal level." (Teaf 2008b, pages 30 and 31) The Stage 2 DBPR will not be implemented for small systems until after 2013. The DBP regulation currently in force is the Stage 1 DBPR.

On page 35 of his report, Teaf (2008a) summarized his concerns regarding health effects of bacteria, DBPs and cyanobacteria:

> "There are biological and chemical hazards and impairments (i.e., bacteria and indicator organisms, THMs/HAA5s, cyanobacteria) within the Illinois River Watershed which are present at levels that are capable of causing damage to human health and which will continue to do so unless action is taken to eliminate the sources or major contributing factors for each of these hazards and impairments. The process of applying poultry waste to fields is a significant contributor to the development and persistence of these hazards and impairments of the IRW. The hazards and impairments represent an imminent and substantial endangerment to human health."

Other experts for the defendants will be addressing the microbial risks. It is my opinion that Dr. Teaf has misrepresented the risks to the public associated with the presence of DBPs and cyanobacteria in the water served by IRW water utilities. No regulatory agency in the State of Oklahoma or at the federal level has ever determined that contaminants in IRW water are "…capable of causing damage to human health…" Therefore, it is not necessary for any action to be taken to "eliminate the sources or major contributing factors for each of these hazards and impairments." Because there are no hazards or impairments except in Dr. Teaf's erroneous opinion, there is certainly no indication that the application of poultry litter to fields is causing health impacts of any kind. Once again, Dr. Teaf is reckless in stating that "The hazards and impairments represent an imminent and substantial endangerment to human health." The State of Oklahoma and the USEPA would have shut down the IRW water utilities or prohibited the use of their water if such a danger existed.

McGuire Expert Opinion #5—Safety of IRW Drinking Water

It is my opinion, based upon a reasonable degree of scientific certainty, that the water served to customers of utilities using the Illinois River and Lake Tenkiller is safe and does not pose a danger to human health.

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